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Project Report

PA-229-4
(RSP)

C. R. Berndtson
R. H. French
D. E. Nessman

Data Reduction Program Documentation
ALTAP

(Effective: April 1971)

19611
2 April 1971

Prepared for the Advanced Research Projects Agency,
the Department of the Army, and the Department of the Air Force
under Electronic Systems Division Contract F19628-70-C-0230 by

Lincoln Laboratory

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Lexington, Massachusetts

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DATA REDUCTION PROGRAM DOCUMENTATION ALTAP (EFFECTIVE: APRIL 1971).

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FOREWORD

This is the fourth report in the Data Reduction Program Documentation series. It is dated according to the date of completion of the documentation. No implication is made that this program will not subsequently be modified, amended, or superseded; on the contrary, the history of radar data processing is one of continuous evolution of techniques, and it is unrealistic to assume that steady-state has been reached. The PA-229 series is being published for the convenience of interested parties, and Lincoln assumes no responsibility for the correctness of the information presented, nor for its currency.

The preparation of reports in this series is under the Editorship of Charles R. Berndtson of Lincoln, and of D. Nessman and R. French of Philco-Ford Corporation. Inquiries, suggestions, corrections, criticisms, and requests for additional copies should be directed to C. R. Berndtson.

The principal contributor to this report was A. J. Poirier (Philco-Ford). Due to the intricate, evolutionary manner in which the programs came into being, the editors regret that it is in general impossible to give due credit to all -- mathematicians or radar analysts or programmers -- who contributed to the definition and writing of the programs.

Alan A. Grometstein

Alan A. Grometstein

CONTENTS

CONTENTS (Cont'd)

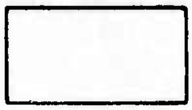
COMMON SYMBOLS AND ABBREVIATIONS

(The units given for certain quantities are the units commonly used for those quantities, unless otherwise noted.)

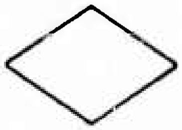
ADT	ALCOR Data Tape
Alt	Altitude (km)
APS	Average Pulse Shape
ARS	ALTAIR Recording System
Avg	Average, Averaging
Az	Azimuth (deg)
CADJ	Adjusted Calibration Constant (db)
C-band	ALCOR frequency, 5664 MHz (NB) and 5667 MHz (WB)
El	Elevation (deg)
EOF	End of File
GMT	Greenwich Mean Time
h	Hours
Hz	Hertz
in	Inches
LC	Left Circular Polarization
min	Minutes
NB	Narrow Band
NRTPOD	Non-real Time Precision Orbit Determination Program
POD	Project PRESS Operation and Data Summary Report
Phase	Presented in deg
PRF	Pulse Repetition Frequency (pps)
PRI	Pulse Repetition Interval (s)
pps	Pulses per second
pts	Points
R	Range (km)
$\dot{R}$	Range Rate (km/s)
rad	Radians
RC	Right Circular Polarization
RCS	Radar Cross Section (dbsm)

s	Seconds
SD_w	Standard Deviation of Wake Velocity
T	Time
TAL	Time After Launch (s)
UHF	ALTAIR Frequency; 415 MHz
V	Velocity
V_d	Doppler Velocity
V_w	Mean Wake Velocity
VHF	ALTAIR Frequency; 155.5 MHz
WB	Wide Band
θ	Total Off-axis Angle (deg)
λ	Wavelength
*	Denotes Multiplication

FLOW DIAGRAM SYMBOLS

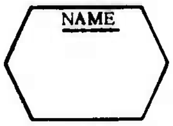


PROCESS, ANNOTATION



DECISION

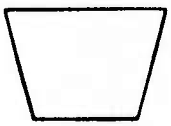
TERMINATOR



SUBROUTINE: where NAME is the entry call into the subroutine

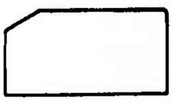
CONNECTOR: where P specifies a page in the flow diagram, and L designates a statement number in the program listing or a reference point in the flow diagram

CONNECTOR: where X implies a continuation of the diagram to the next page

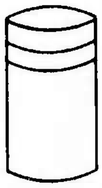


INPUT/OUTPUT OPERATION

MAGNETIC TAPE



PUNCHED CARD



DISK

ALTAP

I. PURPOSE AND UTILIZATION

A. Source of Data

ALTAIR[1]

B. Data Input

ALTAIR transcription tape

C. Description

ALTAP calculates ~~RCS~~ of waking targets during re-entry. It computes ~~RCS~~ for up to 120 range gates. It is normally run every 0.1 s with the data averaged over 0.05 s.

D. Output

1. Plots of RCS vs relative range at altitude increments of approximately 2.5 km or for every averaging interval. Such plots are non-coherent average pulse shapes (APS) which show the position of the wake relative to the body, and display the body and wake RCS.

2. Punched cards containing TAL, Alt, gate no., and RCS if APS plots were obtained every 2.5 km.* These cards may be edited and modified using results of coherent data analysis programs and then used in a plotting program to produce the coherent APS shown in the POD.

3. Punched cards containing TAL, Alt, and RCS of the peak gate. These cards may be edited and modified using results of coherent data processing programs and then used in a plotting program to produce a peak wake plot.

---

*If APS plots were obtained every averaging interval, no punched cards are produced.

→ radar cross sections

4. Listing of RCS every averaging interval for a maximum of 120 gates.

5. Listing of RCS in m^2 in addition to dbsm can be requested.

II. DESCRIPTION

ALTAP computes average RCS for selected gates and time intervals. ALTAP will process only one data channel on one target per run. The averaging interval may be any value larger than the PRI. The program averages in m^2 and then converts to dbsm for printouts and plots.

The altitude on the transcription tape has a resolution of 1 km. Therefore, the altitude used in ALTAP is computed assuming a spherical earth as follows:

$$Alt = (R^2 + R_e^2 + 2RR_e \sin El)^{\frac{1}{2}} - R_e$$

where R_e = radius of earth (6378.145 km).

A number of input parameters and transcription tape parameters are checked for validity before processing.

The main program checks the following input parameters:

$0 < IPOL < 4$

$IPAT = 1$ or 2

$TAVG \neq 0$

$INTARG \neq 0$

$NRG \neq 0$

Subroutine ALREAD[2] makes a number of other checks on transcription tape parameters which are described in detail in the ALREAD description. For some errors (missing format tables; end of file; target no., sampling pattern, or polarization not on tape) information is returned to main program for decision to terminate.

III. OPERATION

A. Input

Start and stop times (GMT)

Averaging interval and skip time*

Target and sampling pattern numbers

Specified set of range gates

Initial gate for computing peak wake RCS

Alt to start APS plots

Options for punching and plotting data

A sample ALTAP input is shown in Appendix A.

CARD 1 (15A4)

(Col.)		
1-60	TITLE	60 character title for printout and plots.

CARD 2 (2I3, F7.3, 2I3, F7.3, 4X, 5I5, 2F10.3)

1- 3	IH1 (I3)	Start time (GMT) in h, min, and s
4- 6	IM1 (I3)	
7-13	ZSEC1 (F7.3)	
14-16	IH2 (I3)	Stop time (GMT) in h, min, and s
17-19	IM2 (I3)	
20-26	ZSEC2 (F7.3)	
31-35	NRG	Number of range gates (I5)
36-40	INTARG	Target no. (I5)
41-45	IPAT **	Sampling pattern in which initial gate is located. (I5)
46-50	IPOL	Data channel; 1 = LC; 2 = RC; 3 = Az error †; 4 = El error † (I5)
51-55	ISG ††	Location within IPAT of initial gate (I5)

* Skip time is the time in seconds from the end of one averaging interval to the start of the next.

** Also called INPAT.

† VHF transcriptions only.

†† Also called ING and ISTGAT.

(Col.)		
56-65	TAVG	Averaging interval in seconds (F10.3)
66-75	TSKIP	Skip time in seconds (F10.3)

CARD 3 (I5, 3F10.3, 3I5)

1- 5	ISTGT	The gate location, relative to ISG, in which to start looking for peak wake. If 0, the gate location is set to 1. (I5)
6-15	REQAL	The altitude at which to start the APS plotted at altitude intervals. (F10.3) This must be on tape within time interval being processed.
16-25	YMIN	The minimum ordinate of the APS plots in dbsm. If 0, the ordinate is set to -60.0 dbsm. (F10.3)
26-35	YMAX	The maximum ordinate of the APS plots in dbsm. If 0, the ordinate is set to +40.0 dbsm. (F10.3)
36-40	ISQM	1 : printed output in m^2 and dbsm. 0 : printed output in dbsm only. (I5)
41-45	IOPT	If > 0, program will plot every averaging interval. (I5) If ≤ 0, program will plot every altitude interval.
46-50	IPUN	If ≠ 0, program will punch peak wake data. (I5) If 0, punched peak wake cards not produced.

B. Output

LISTING

GMT and TAL, Alt, and R for mid-point of averaging interval

Frequency and polarization

Average RCS for each gate; Average RCS (m^2) for each gate (when requested).

Number of pulses used in averaging interval and CADJ

APS PLOTS

RCS vs relative range (m)

PUNCHED PEAK WAKE DATA

Alt (F10.3), RCS (F10.3), gate no. (I5)

PUNCHED APS DATA AT ALTITUDE INTERVALS *

Alt (F10.3), TAL (F10.3)

RCS (F10.3), gate no. (I5)
(1 card for each gate selected)

Sample ALTAP outputs are given in Appendix B.

* Produced only when IOPT $\leq$ 0 and REQAL is input.

IV. PROGRAM LIMITATIONS

Start time	Must be on tape
Stop time	Must be on tape
NRG	$\leq$ 120 gates
TAVG	Must be larger than the PRI
TSKIP	Cannot be negative
INTARG	Must be on tape within start and stop times
Length of run	With no punched cards: no limit. With punched cards: $\leq$ 300 averaging intervals

V. PROGRAMMING

A. TAPOS (see Appendices C and D.)

TAPOS is the control section of ALTAP. TAPOS reads the input cards, calls ALREAD, and averages the data returned. TAPOS also calls the plot routines, and prints and punches all data.

B. PEAK (see Appendices E and F.)

PEAK searches an array of RCS to find the largest value; it saves this value and the gate number of the value. PEAK then passes these values back to TAPOS. A location within the array of RCS may be specified to start the search.

The call statement is PEAK (AVGAL, NRG, ISTGT, IRGA, AVGSX, ISPOT).

INPUT

AVGAL	Alt *
NRG	Number of range gates
ISTGT	Start gate for peak relative to ISG
IRGA	Array of gate nos.
AVGSX	Array of RCS for gates

OUTPUT

ISPOT	Peak gate identification

STORED IN COMMON

INN	Running number of averaging intervals
GTMAX	Array of peak RCS*
ALT	Array of altitudes*
IGAT	Array of peak gate nos.*

* One value for each averaging interval.

C. ALTIT (see Appendices G and H.)

ALTIT computes Alt by using R, El, and the radius of the earth, and returns this value to TAPOS.

The call statement is ALTIT (AVGAL, AVGRG, AVGEL).

INPUT

AVGRG	R*
AVGEL	El*

OUTPUT

AVGAL	Alt*

D. REFC (see Appendix J.)

ALTIT calls REFC. The tropospheric refraction correction subroutine, REFC, is based on tropospheric refraction tables in PPP-36.[3] A modified version of this subroutine is now in use.

The call statement is REFC (E, R, DEE, DRR).

E	=	Uncorrected El (must be between 0 and 90)
R	=	Uncorrected R (ft)
DEE	=	El tropospheric correction
DRR	=	R tropospheric correction (ft)

The corrected values to be computed after exiting from the REFC subroutine are:

El	=	E-DEE
R (ft)	=	R-DRR

* For midpoint of averaging interval

E. BLOTO

BLOTO plots RCS vs relative range (m) every altitude or every averaging interval. The ordinate is variable through the optional input of YMIN and YMAX. Nominal values for these are -60.0 dbsm and +40.0 dbsm, respectively.

F. TSPLIT (see Appendix K.)

TSPLIT is used to convert time from GMT total seconds to h, min, s, and decimal fractions of s.

The call statement is TSPLIT (AVGTM, IHM, TRUN).

INPUT

AVGTM	GMT total seconds

OUTPUT

IHM (1)	Hours
IHM (2)	Minutes
TRUN	Seconds and decimal fractions of seconds

G. ALREAD[2]

ALREAD is the Fortran driver for the machine language tape reading routines.

The call statement is ALREAD (TSTART, TSTOP, TLIFT, INTARG, INPAT, IPOL, NOPHA, NPTS, DFPG, NEWPAS, NRG, ISTGAT).

INPUT

TSTART	Start time of processing (GMT total seconds)
TSTOP	End time of processing (GMT total seconds)
INTARG	Target number to be processed

INPAT	Sampling pattern in which initial gate is located
NRG	Number of range gates to be processed
ISTGAT	Location within INPAT of initial gate wanted
NOPHA	1 (only RCS data wanted)
IPOL	Data channel: 1 = LC; 2 = RC; 3 = Az error; 4 = El error

INPUT and OUTPUT PARAMETERS

NPTS*	Output: number of pulses of data returned
	Input: must be initialized by calling program before each call to ALREAD
NEWPAS**	Cycle and error pointer

OUTPUT

TLIFT	Lift-off time (GMT total seconds)
DFPG	Frequency and polarization (e.g. VHF LC)

VALUES STORED IN COMMON

TIMES	Pulse times (GMT total seconds)
XSPHA	RCS and phase for each pulse and gate
RANGKM	R
ELSAV	El (rad)
CALOUT†	Adjusted calibration constant
IRGA	Range gate array associated with XSPHA
NFPG	Frequency code: 1 = VHF; 2 = UHF

*Set to zero for first call. Set to number of saved points for subsequent calls.
**Also called IAGAIN.
†Also called CADJ.

H. REW

REW is an entry to subroutine BREADS[4] used to rewind the tape.

J. Plotting System Subroutines

They are RFREAD, STOIDV, and PLTND.

REFERENCES

1. "ALTAIR Data User's Manual", LM-97, Lincoln Laboratory, M.I.T. (to be published), UNCLASSIFIED.
2. "Data Reduction Program Documentation, ALREAD, (Effective: March 1971)", PA-229-3, Lincoln Laboratory, M.I.T. (17 March 1971), UNCLASSIFIED.
3. J.P. Penhune, "Refraction Corrections for the TRADEX Radar", PPP-36, Lincoln Laboratory, M.I.T. (21 April 1965), UNCLASSIFIED.
4. "Data Reduction Program Documentation, ALTAIR Tape Read Package, (Effective: April 1970)", PA-229-1, Lincoln Laboratory, M.I.T. (17 March 1971), UNCLASSIFIED.

APPENDIX A

ALTAP INPUT

ALTAP F1164

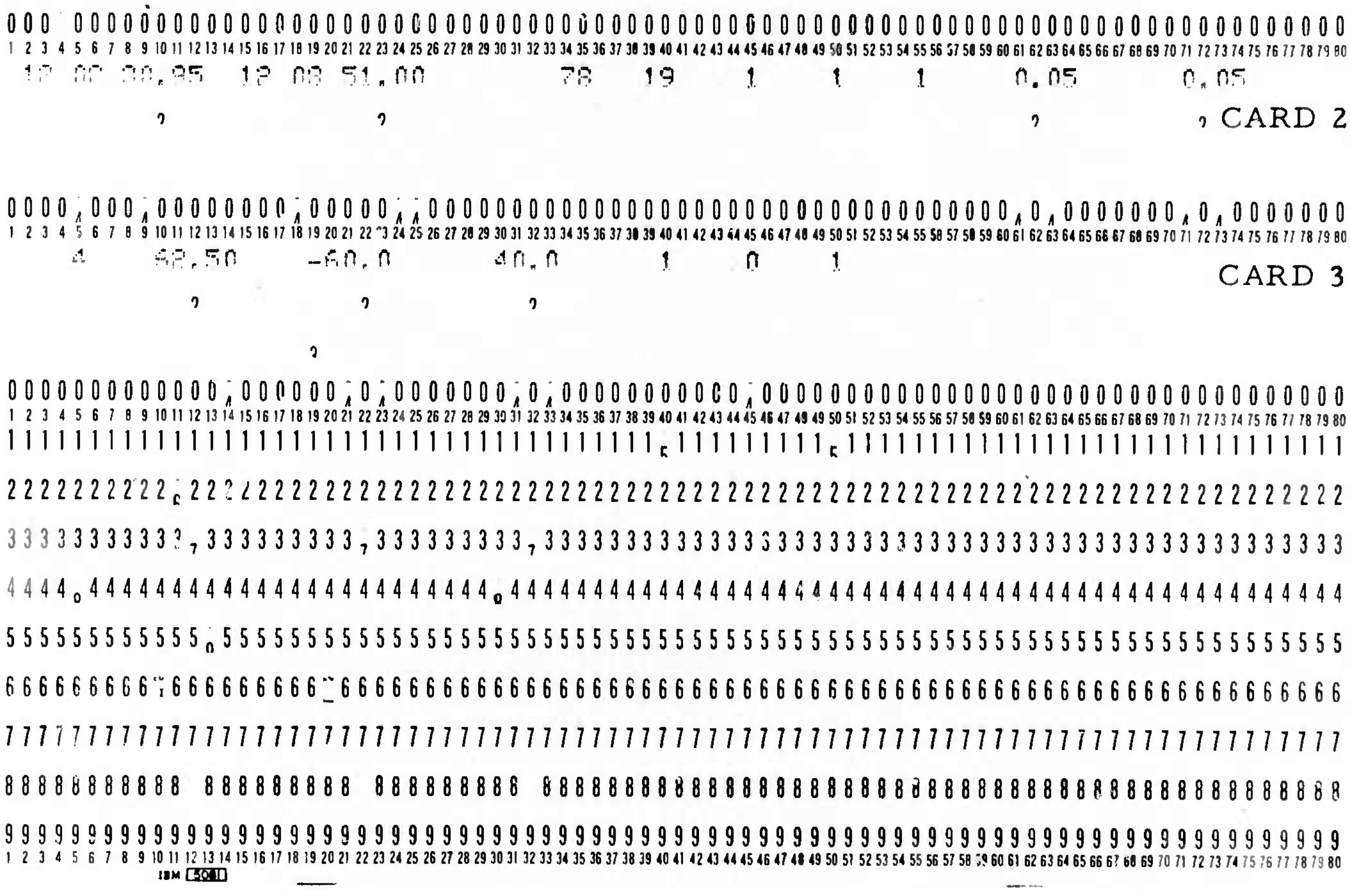
CARD 1

12 00 20.95   12 08 51.00   78   19   1   1   1   0.05   0.05

CARD 2

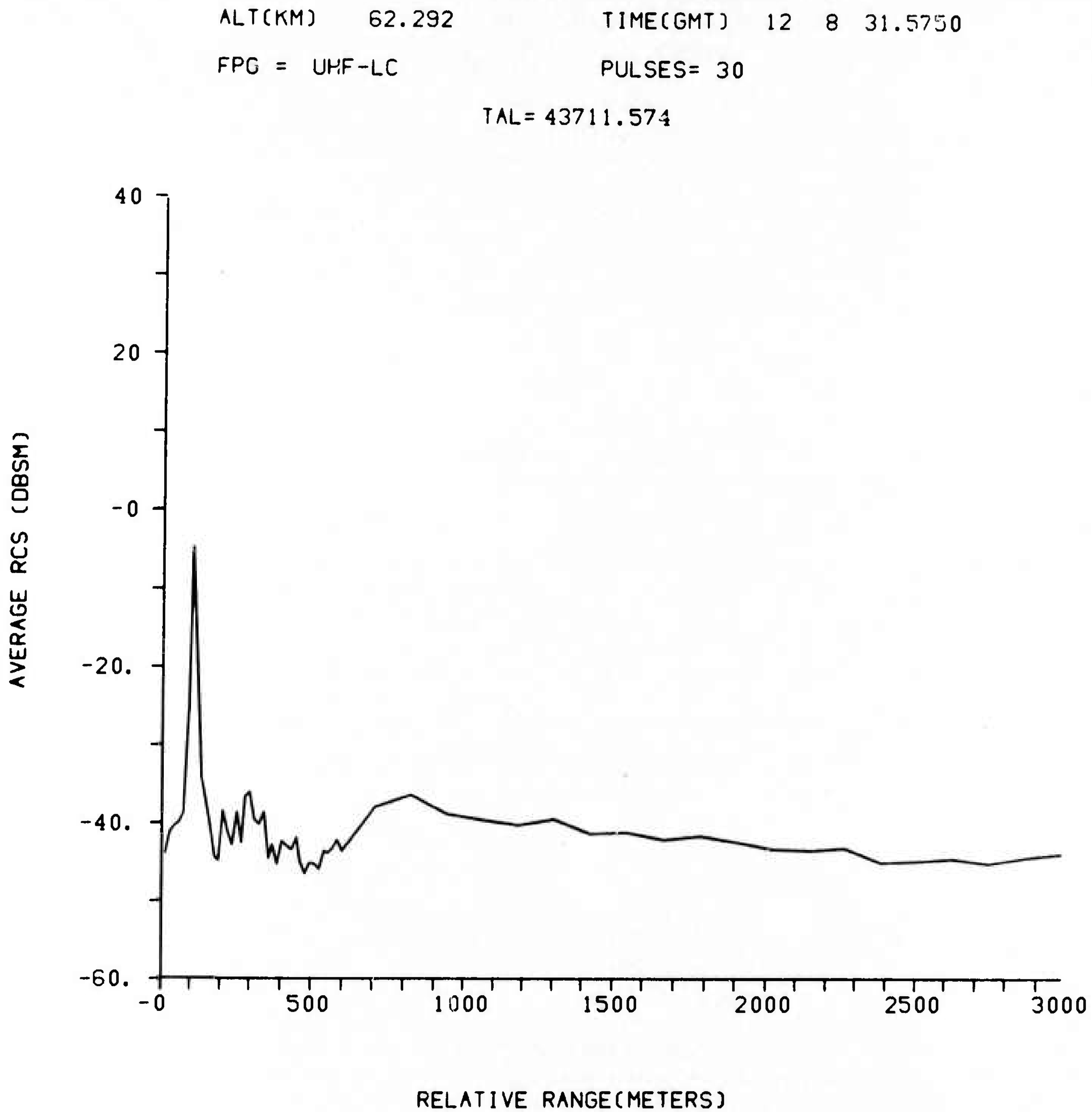
4   62.50   -60.0   40.0   1   0   1

CARD 3



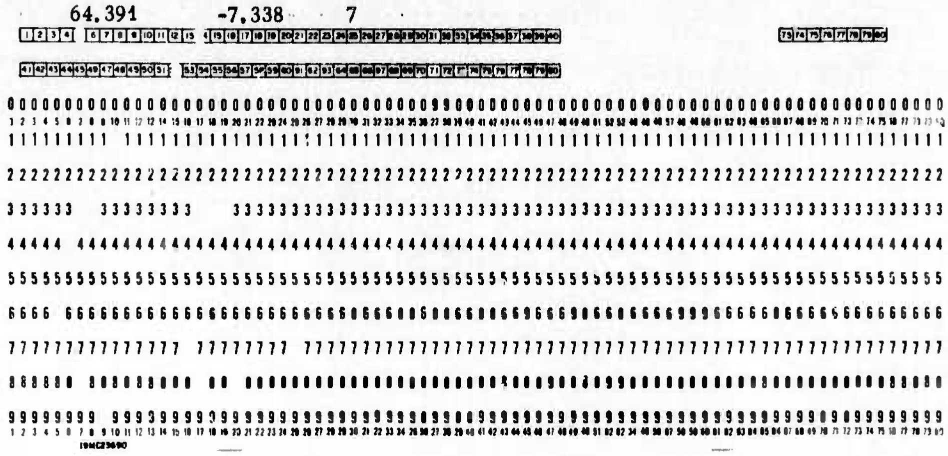
APPENDIX B
ALTAP OUTPUTS

```
ALTAIR TAP VERSION  13 FEB 1971

ALTAP 31164 LC (2)
TARGET NUMBER =     19


 TIME(GMT) =  12  8 30.9748    43710.9748  RANGE(KM) =     173.648  ALT(KM) =      64.391    29 PULSES  CADJ =      10.547
RANGE GATES      1     2     3     4     5     6     7*    8     9    10    11    12    13    14    15    16    17    1
FPG = UHF-LC   -42.3 -38.8 -36.8 -39.5 -37.2 -23.1  -2.0 -16.3 -31.3 -34.9 -38.3 -43.3 -44.2 -37.1 -39.7 -42.9 -35.8 -40
RANGE GATES     19    20    21    22    23    24    25    26    27    28    29    30    31    32    33    34    35    3
FPG = UHF-LC   -34.1 -34.8 -38.1 -38.0 -37.0 -42.4 -38.4 -43.2 -44.0 -43.4 -44.4 -42.0 -44.9 -43.2 -43.0 -45.1 -44.2 -43
RANGE GATES     37    38    39    40    47    55    63    71    79    87    95   103   111   119   127   135   143   15
FPG = UHF-LC   -45.4 -44.4 -45.0 -45.7 -46.8 -44.1 -43.5 -39.5 -41.5 -42.2 -47.3 -44.1 -41.7 -43.9 -44.3 -42.9 -44.5 -43
RANGE GATES    159   167   175   183   191   199   207   215   223   231   239   247   255   263   271   279   287   29
FPG = UHF-LC   -43.7 -44.0 -45.3 -44.7 -44.2 -43.6 -44.1 -43.5 -43.1 -44.9 -45.1 -42.3 -45.2 -44.5 -42.3 -4 .2 -43.1 -45.1
RANGE GATES    303   311   319   327   335   343
FPG = UHF-LC   -43.7 -43.4 -45.1 -40.0 -34.4 -34.4

  TIME(GMT) =  12  8 30.9748  TIME(TSEC) =    43710.9748  RANGE(KM) =     173.648  ALT(KM) =      64.391    29 PULSES
RANGE GATES         1          2          3          4          5          6          7          8          9
SQUARE METERS   5.867E-05  1.324E-04  2.084E-04  1.120E-04  1.904E-04  4.944E-03  6.372E-01  2.334E-02  7.374E-04
RANGE GATES        10         11         12         13         14         15         16         17         18
SQUARE METERS   3.223E-04  1.476E-04  4.678E-05  3.835E-05  1.944E-04  1.084E-04  5.165E-05  2.614E-04  8.040E-05
RANGE GATES        19         20         21         22         23         24         25         26         27
SQUARE METERS   3.925E-04  3.298E-04  1.565E-04  1.602E-04  2.015E-04  5.716E-05  1.438E-04  4.839E-05  3.967E-05
RANGE GATES        28         29         30         31         32         33         34         35         36
SQUARE METERS   4.334E-05  3.638E-05  6.267E-05  3.259E-05  4.826E-05  4.956E-05  3.073E-05  3.803E-05  4.516E-05
RANGE GATES        37         38         39         40         47         55         63         71         79
SQUARE METERS   2.895E-05  3.604E-05  3.169E-05  2.709E-05  2.101E-05  3.873E-05  4.442E-05  1.110E-04  7.121E-05
RANGE GATES        87         95        103        111        119        127        135        143        151
SQUARE METERS   5.971E-05  1.861E-05  3.907E-05  6.702E-05  4.077E-05  3.678E-05  5.111E-05  3.584E-05  4.371E-05
RANGE GATES       159        167        175        183        191        199        207        215        223
SQUARE METERS   4.265E-05  3.948E-05  2.971E-05  3.424E-05  3.843E-05  4.328E-05  3.929E-05  4.518E-05  4.878E-05
RANGE GATES       231        239        247        255        263        271        279        287        295
SQUARE METERS   3.237E-05  3.066E-05  5.867E-05  2.993E-05  3.466E-05  5.241E-05  4.733E-05  4.895E-05  3.060E-05
RANGE GATES       303        311        319        327        335        343
SQUARE METERS   4.226E-05  4.554E-05  3.118E-05  9.897E-05  3.631E-04  3.596E-04

 TIME(GMT) =  12  8 31.0751    43711.0751  RANGE(KM) =     172.980  ALT(KM) =      64.051    29 PULSES  CADJ =      10.485
RANGE GATES      1     2     3     4     5     6     7*    8     9    10    11    12    13    14    15    16    17    18
FPG = UHF-LC   -42.8 -39.2 -37.6 -38.7 -37.2 -23.0  -2.7 -17.3 -32.6 -35.3 -38.6 -42.6 -43.7 -37.4 -40.2 -43.3 -37.6 -41.3
RANGE GATES     19    20    21    22    23    24    25    26    27    28    29    30    31    32    33    34    35    36
FPG = UHF-LC   -33.4 -35.0 -38.0 -38.6 -37.9 -42.7 -39.0 -42.1 -43.1 -45.3 -45.4 -44.1 -45.5 -44.4 -43.2 -45.4 -45.8 -44.5
RANGE GATES     37    38    39    40    47    55    63    71    79    87    95   103   111   119   127   135   143   151
FPG = UHF-LC   -45.2 -44.2 -44.4 -45.5 -45.7 -44.4 -42.2 -41.5 -40.8 -39.9 -41.9 -40.9 -43.7 -41.8 -42.9 -43.3 -46.1 -42.6
RANGE GATES    159   167   175   183   191   199   207   215   223   231   239   247   255   263   271   279   287   295
FPG = UHF-LC   -44.4 -43.8 -43.0 -45.2 -43.9 -46.0 -43.8 -45.2 -43.9 -44.1 -44.4 -43.8 -43.4 -43.0 -42.7 -42.9 -44.4 -43.8
RANGE GATES    303   311   319   327   335   343
FPG = UHF-LC   -45.5 -43.4 -44.0 -38.7 -34.6 -35.4

  TIME(GMT) =  12  8 31.0751  TIME(TSEC) =    43711.0751  RANGE(KM) =     172.980  ALT(KM) =      64.051    29 PULSES
RANGE GATES         1          2          3          4          5          6          7          8          9
SQUARE METERS   5.254E-05  1.200E-04  1.743E-04  1.352E-04  1.838E-04  5.012E-03  5.336E-01  1.854E-02  5.445E-04
RANGE GATES        10         11         12         13         14         15         16         17         18
SQUARE METERS   2.926E-04  1.366E-04  5.527E-05  4.223E-05  1.806E-04  9.555E-05  4.677E-05  1.742E-04  7.436E-05
RANGE GATES        19         20         21         22         23         24         25         26         27
SQUARE METERS   4.613E-04  3.192E-04  1.570E-04  1.381E-04  1.610E-04  5.405E-05  1.268E-04  6.164E-05  4.922E-05
RANGE GATES        28         29         30         31         32         33         34         35         36
SQUARE METERS   2.948E-05  2.908E-05  3.860E-05  2.788E-05  3.628E-05  4.811E-05  2.665E-05  2.624E-05  3.546E-05
RANGE GATES        37         38         39         40         47         55         63         71         79
SQUARE METERS   3.005E-05  3.831E-05  3.641E-05  2.845E-05  2.698E-05  3.654E-05  6.081E-05  7.054E-05  8.395E-05
RANGE GATES        87         95        103        111        119        127        135        143        151
```


ALT(KM) 62.292
TIME(GMT) 12 8 31.5750
FPG = UHF-LC
PULSES= 30
TAL= 43711.574
AVERAGE RCS (DBSM)
40
20
-0
-20.
-40.
-60.
-0
500
1000
1500
2000
2500
3000
RELATIVE RANGE(METERS)

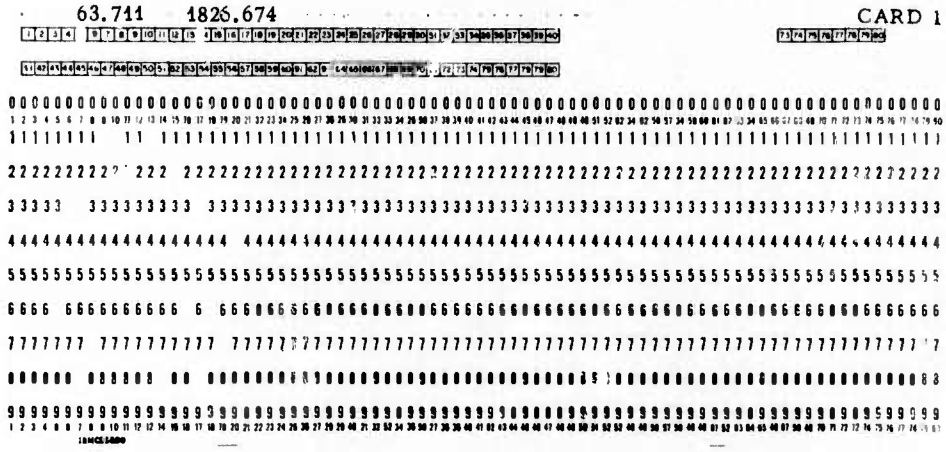
PEAK WAKE DATA

ALT 64.391 RCS -7.338 GATE NO. 7

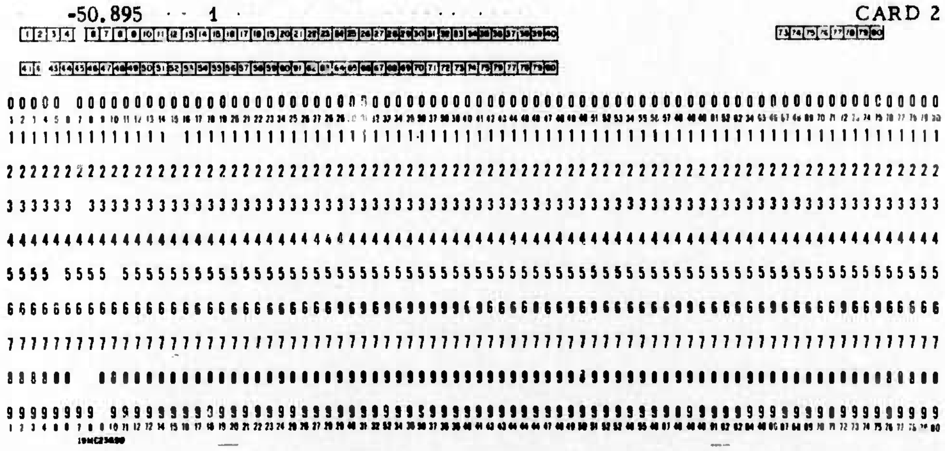


APS DATA

ALT 63.711 TAL 1826.674 CARD 1



RCS -50.895 GATE NO. 1 CARD 2



APPENDIX C
TAPOS PROGRAM LISTING

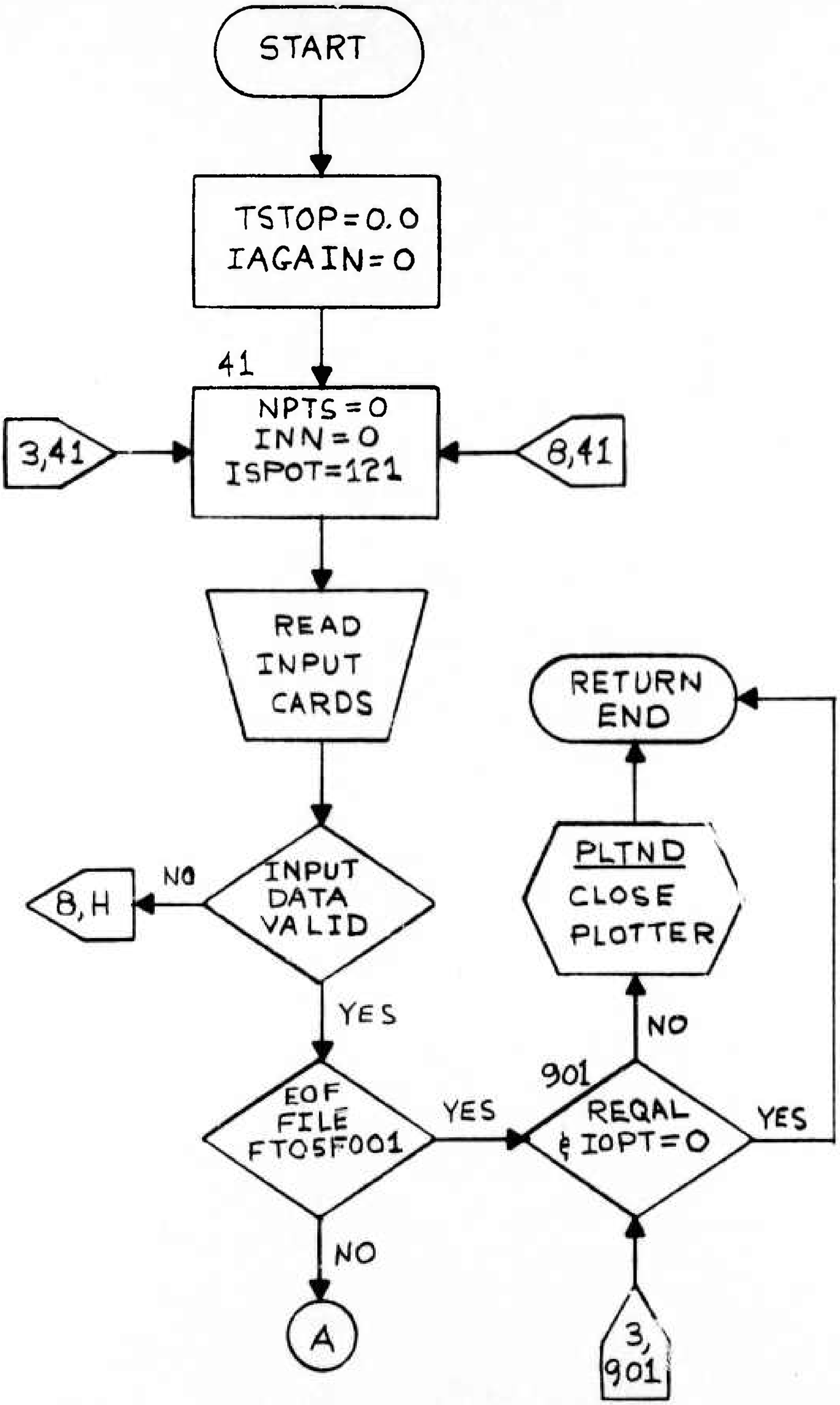
```
      DIMENSION DFPG(2),SUMSX(120),AVGSX(120),IDENT(15),IHM(2),
     1GTMAX(3000),ALT(3000),IGAT(3000),UPLOG(120),ISTAR(121)
      EQUIVALENCE(IHM(1),IHR),(IHM(2),IMIN)
      COMMON/RDCONT/TIMES(300),XSPHA(120,300),RANGKM(300),ELSAV(300),
     1CALOUT(300),IRGA(120),NPFG
      COMMON/PEEK/INN,GTMAX,ALT,IGAT
      DOUBLE PRECISION AVGTM,SEC,SUMTM,T1,T2,TIMES,TOTIM,TSTART,TSTOP,
     1TSV,ZSEC,ZSEC1,ZSEC2,TLIFT
      DATA IAST/'*'/
      DATA ISTAR/121*'    '/
      DATA IBLANK/'    '/
      DATA UPLOG/120*0.0/
      DATA SUMSX/120*0.0/
      DATA AVGSX/120*0.0/
      TOTIM(IH,IM,SEC)=DFLOAT(60*(60*IH+IM))+SEC
      TSTOP=0.0
      IAGAIN=0
   41 SUMTM=0.0
      ISPOT=121
      NPTS=0
      INN=0
      READ(5,20,END=901)IDENT
   20 FORMAT(15A4)
      READ(5,60,END=901)IH1,IM1,ZSEC1,IH2,IM2,ZSEC2,NRG,INTARG,IPAT,IPOL
     1,ISG,TAVG,TSKIP
   60 FORMAT(2(2I3,F7.3),4X,5I5,2F10.3)
      READ(5,61)ISTGT,REQAL,YMIN,YMAX,ISQM,IOPT,IPUN
   61 FORMAT(I5,3F10.3,3I5)
      IF(ISTGT.EQ.0)ISTGT=1
      WRITE(6,64)
   64 FORMAT(5X,'THESE ARE YOUR INPUT CARDS')
      WRITE(6,62)IH1,IM1,ZSEC1,IH2,IM2,ZSEC2,NRG,INTARG,IPAT,IPOL,
     1ISG,TAVG,TSKIP
   62 FORMAT(2(2I3,F7.3),4X,5I5,2F10.3)
      WRITE(6,63)ISTGT,REQAL,YMIN,YMAX,ISQM,IOPT,IPUN
   63 FORMAT(I5,3F10.3,3I5)
      IF(NRG.EQ.0)GO TO 550
      IF(INTARG.EQ.0)GO TO 560
      IF((IPAT.EQ.0).OR.(IPAT.GT.3))GO TO 570
      IF((IPOL.EQ.0).OR.(IPOL.GT.4))GO TO 580
      IF(TAVG.EQ.0.0)GO TO 590
   70 TSTART=TOTIM(IH1,IM1,ZSEC1)
      IF((TSTART.GT.TSTOP).AND.(IAGAIN.NE.44))GO TO 72
      CALL REW
      IAGAIN=1
   72 TSTOP=TOTIM(IH2,IM2,ZSEC2)
      IF((REQAL.EQ.0.0).AND.(IOPT.EQ.0))GO TO 75
      CALL STOIDV(IDENT,59,0)
   75 CALL REREAD(99,530)
      COUNT=0
      KOUNT=0
      INT=0
      T1=TSTART
      T2=T1+TAVG
  100 CALL ALREAD(TSTART,TSTOP,TLIFT,INTARG,IPAT,IPOL,1,NPTS,DFPG,IAGAIN
```

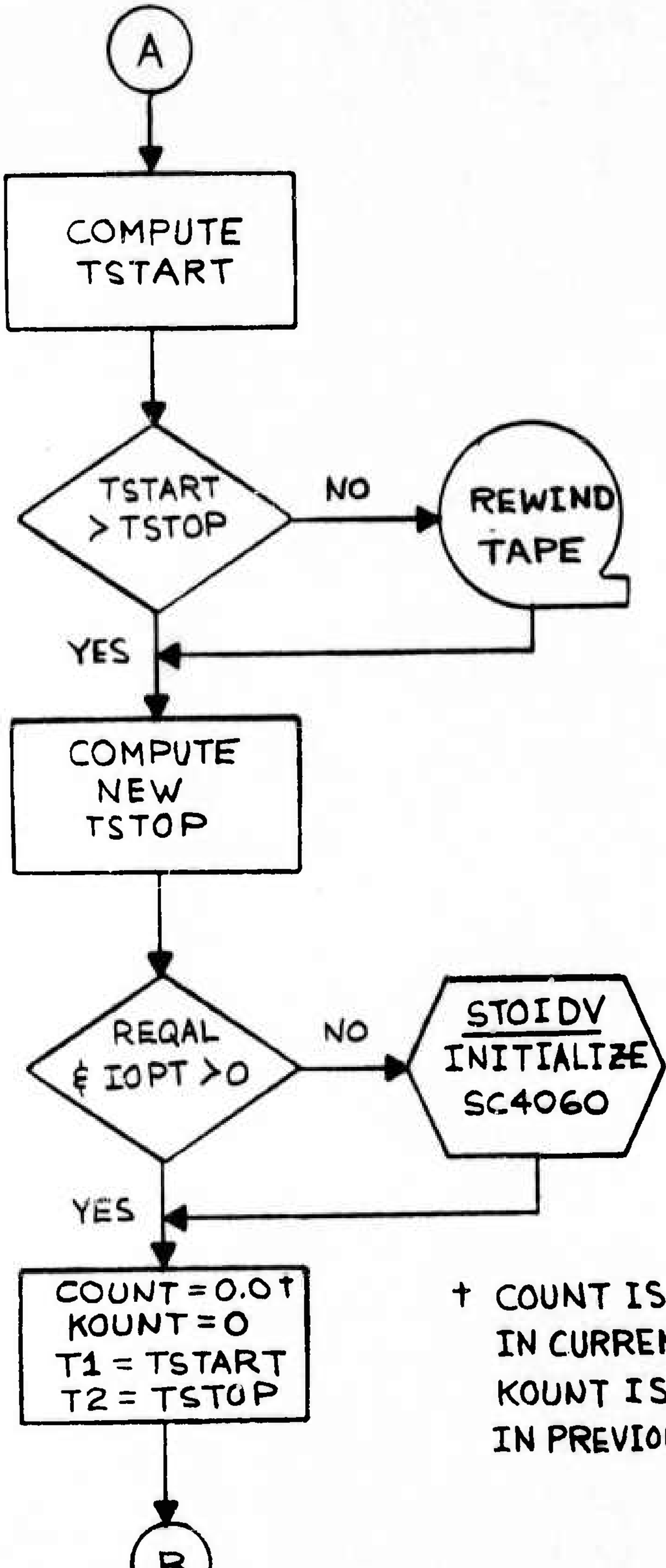
```
     1,NRG,ISG)
      IF(IAGAIN.EQ.44)GO TO 510
      IF(IAGAIN.EQ.55)GO TO 901
      IF(NPTS.EQ.0)GO TO 41
      IF(INT.EQ.0)WRITE(6,140)IDENT,INTARG
  140 FORMAT('1',30X' ALTAIR TAP VERSION  19 FEB 1971   '//31X,
     115A4/31X,'TARGET NUMBER = ',I5//)
      INT=1
      DO 220 I=1,NPTS
  160 IF(TIMES(I).GT.T2)GO TO 240
      IF(T1.GT.TIMES(I))GO TO 220
      INPT=I
      IF(SUMTM.NE.0.0)GO TO 180
      SUMTM=TIMES(I)
      SUMRG=RANGKM(I)
      SUMEL=ELSAV(I)
      CALSV=CALOUT(I)
  180 DO 200 K=1,NRG
      EXTEN=(XSPHA(K,I)/10.)
      IF(EXTEN.GT.75.0)GO TO 245
      XSPHA(K,I)=10.**EXTEN
      SUMSX(K)=SUMSX(K)+XSPHA(K,I)
  200 CONTINUE
      TSV=TIMES(I)
      RSV=RANGKM(I)
      ESV=ELSAV(I)
      COUNT=COUNT+1
  220 CONTINUE
      IF(IAGAIN.EQ.0)GO TO 240
      NPTS=0
      GO TO 100
  240 IF(COUNT.NE.0.0)GO TO 280
  245 WRITE(6,260)T2,EXTEN
  260 FORMAT(/25X'AT TIME = 'F12.4,2X'THERE IS A TIME  GAP OR BAD DATA
     1 EXTEN = ',F10.4)
      GO TO 440
  280 DO 340 J=1,NRG
      UPLOG(J)=SUMSX(J)/COUNT
      IF(UPLOG(J).GT.0.0)GO TO 300
      AVGSX(J)=99.99
      GO TO 320
  300 AVGSX(J)=10.*ALOG10(UPLOG(J))
  320 SUMSX(J)=0.0
  340 CONTINUE
      AVGTM=(SUMTM+TSV)/2.
      AVGRG=(SUMRG+RSV)/2.
      AVGEL=(SUMEL+ESV)/2.
      IK=IFIX(COUNT)
      IKT=IABS(KOUNT-IK)
      IF((KOUNT.NE.0).AND.(IKT.GT.2))GO TO 424
      KOUNT=IFIX(COUNT)
      KOUNT=COUNT
      CALL TSPLIT(AVGTM,IHM,ZSEC)
      AVGTM=AVGTM-TLIFT
      CALL ALTIT(AVGAL,AVGRG,AVGEL)
```

```
      IF((REQAL.EQ.0.0).AND.(IOPT.EQ.0))GO TO 358
      CALL BLOTO(AVGAL,REQAL,NRG,YMIN,YMAX,COUNT,DFPG,IRGA,AVGSX,ZSEC,
     1IMIN,IHR,NFPG,AVGTM,IOPT)
  358 IF(ISTGT.EQ.0)GO TO 359
      CALL PEAK(AVGAL,NRG,ISTGT,IRGA,AVGSX,ISPOT)
  359 WRITE(6,360)IHR,IMIN,ZSEC,AVGTM,AVGRG,AVGAL,KOUNT,CALSV
  360 FORMAT(/2X'TIME(GMT) = ',2I3,F8.4,2X,F12.4,2X,'RANGE(KM) = ',
     1F10.3,2X,'ALT(KM) = ',F10.3,2X,I4,' PULSES',2X,'CADJ = ',F10.3)
      IN=1
      ISTAR(ISPOT)=IAST
  380 IOUT=IN+17
      IF(IOUT.GT.NRG) IOUT=NRG
      WRITE(6,400) (IRGA(L),ISTAR(L),L=IN,IOUT)
  400 FORMAT(1X'RANGE GATES'3X,18(I5,A1))
      WRITE(6,420) DFPG,(AVGSX(L),L=IN,IOUT)
  420 FORMAT(1X,'FPG = ',2A4,18F6.1)
      IN=IOUT+1
      IF(IN.LE.NRG) GO TO 380
      ISTAR(ISPOT)=IBLANK
      IF(ISQM.LT.1)GO TO 440
      WRITE(6,421) IHR,IMIN,ZSEC,AVGTM,AVGRG,AVGAL,KOUNT
  421 FORMAT(/2X' TIME(GMT) = ',2I3,F8.4,2X'TIME(TSEC) = ',F12.4,2X,
     1'RANGE(KM) = ',F10.3,2X,'ALT(KM) = ',F10.3,2X,I4,' PULSES')
      NI=1
  427 ITUO=NI+8
      IF(ITUO.GT.NRG)ITUO=NRG
      WRITE(6,422) (IRGA(L),L=NI,ITUO)
  422 FORMAT(1X'RANGE GATES'9I12)
      WRITE(6,423) (UPLOG(L),L=NI,ITUO)
  423 FORMAT(1X'SQUARE METERS',1P9E12.3)
      NI=ITUO+1
      IF(NI.LE.NRG)GO TO 427
      GO TO 440
  424 KOUNT=0
      WRITE(6,425)AVGTM,IK
  425 FORMAT(/2X'AT TIME =',F10.3,' THERE WAS A PRF CHANGE THE NUMBER OF
     1 PULSES WAS ',I5)
  440 COUNT=0
      T1=T2+TSKIP
      T2=T1+TAVG
      SUMTM=0.0
      SUMRG=0.0
      SUMAL=0.0
      IF(T2.LE.TIMES(NPTS))GO TO 160
      IF(T2.GT.TSTOP)GO TO 510
      DO 460 K=INFT,NPTS
      KNPT=K
      IF(T1.LE.TIMES(K)) GO TO 480
  460 CONTINUE
  480 ND=NPTS-KNPT+1
      DO 500 N=1,ND
      NL=KNPT+N-1
      TIMES(N)=TIMES(NL)
      RANGKM(N)=RANGKM(NL)
      ELSAV(N)=ELSAV(NL)
```

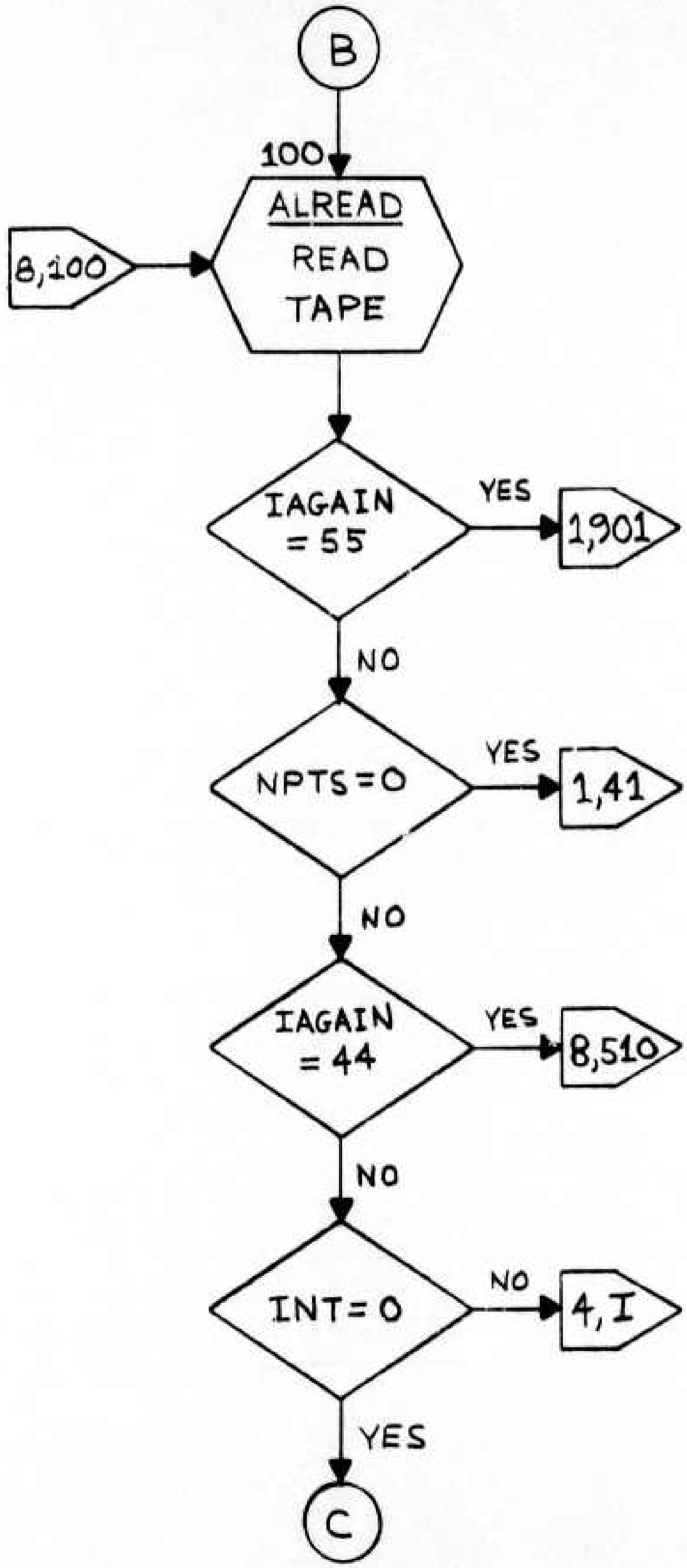
```
      CALOUT(N)=CALOUT(NL)
      DO 500 L=1,NRG
      XSPHA(L,N)=XSPHA(L,NL)
500   CONTINUE
      NPTS=ND
      IF(IAGAIN.NE.0)GO TO 100
  510 IF(IPUN.EQ.0)GO TO 900
      WRITE(7,511) (ALT(M),GTMAX(M),IGAT(M),M=1,INN)
  511 FORMAT(2F10.3,I5)
      GO TO 900
 550  WRITE(6,555)
 555  FORMAT(//2X'A ZERO VALUE WAS INPUT FOR NRG THIS IS A NO NO')
      GO TO 900
 560  WRITE(6,565)
  565 FORMAT(//2X'A ZERO VALUE WAS INPUT FOR THE TARGET #, THE DATA EDIT
     1OR HAS GOOFFED AGAIN')
      GO TO 900
 570  WRITE(6,575)IPAT
 575  FORMAT(//2X'A VALUE OF',I5,'  WAS INPUT FOR IPAT THE ONLY LEGAL VA
     1LUES FOR IPAT ARE 1,2,3')
      GO TO 900
 580  WRITE(6,585)IPOL
 585  FORMAT(//2X'A VALUE OF',I5,'  WAS INPUT FOR IPOL THE ONLY LEGAL VA
     1LUES FOR IPOL ARE 1,2,3,4')
      GO TO 900
 590  WRITE(6,595)
 595  FORMAT(//2X'A ZERO VALUE FOR TINC CAN NOT WORK IT WILL BE SET TO
     10.05 SECONDS AND THE PROGRAM WILL CONTINUE')
      TAVG=0.05
      GO TO 70
  900 IAGAIN=99
      GO TO 41
  901 IF((REQAL.EQ.0.0).AND.(IOPT.EQ.0)) GO TO 902
      CALL PLTND
 902  RETURN
      END
```

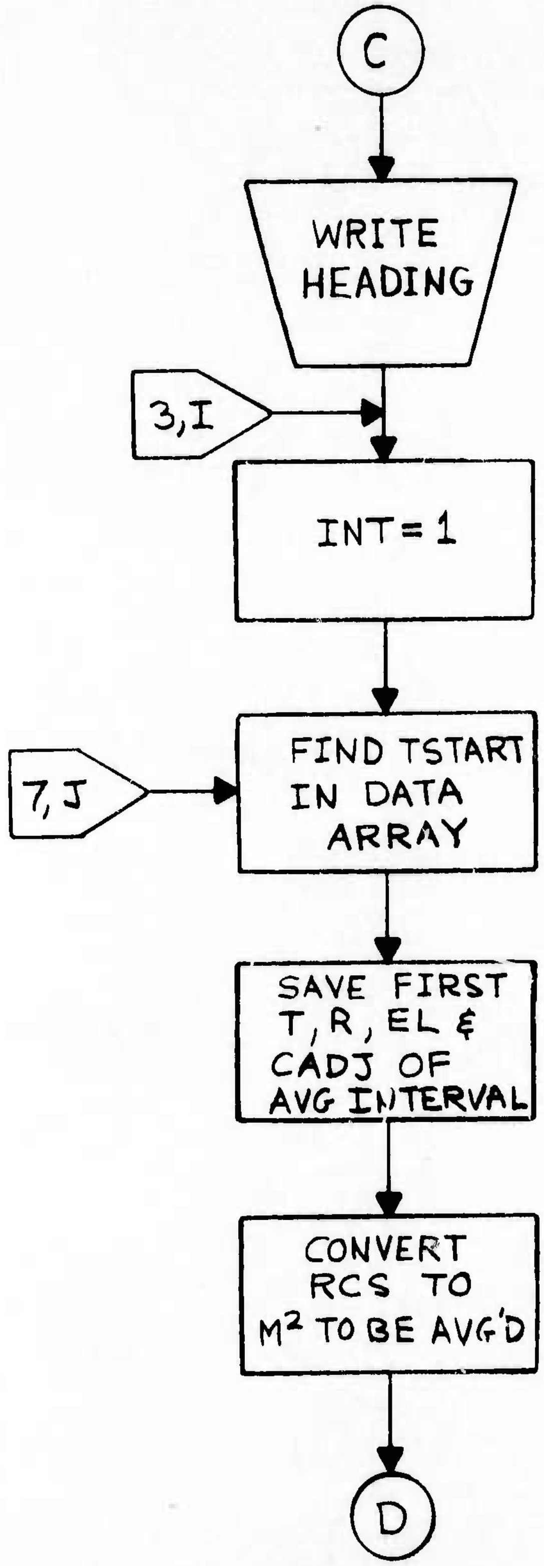
APPENDIX D
TAPOS FLOW DIAGRAM

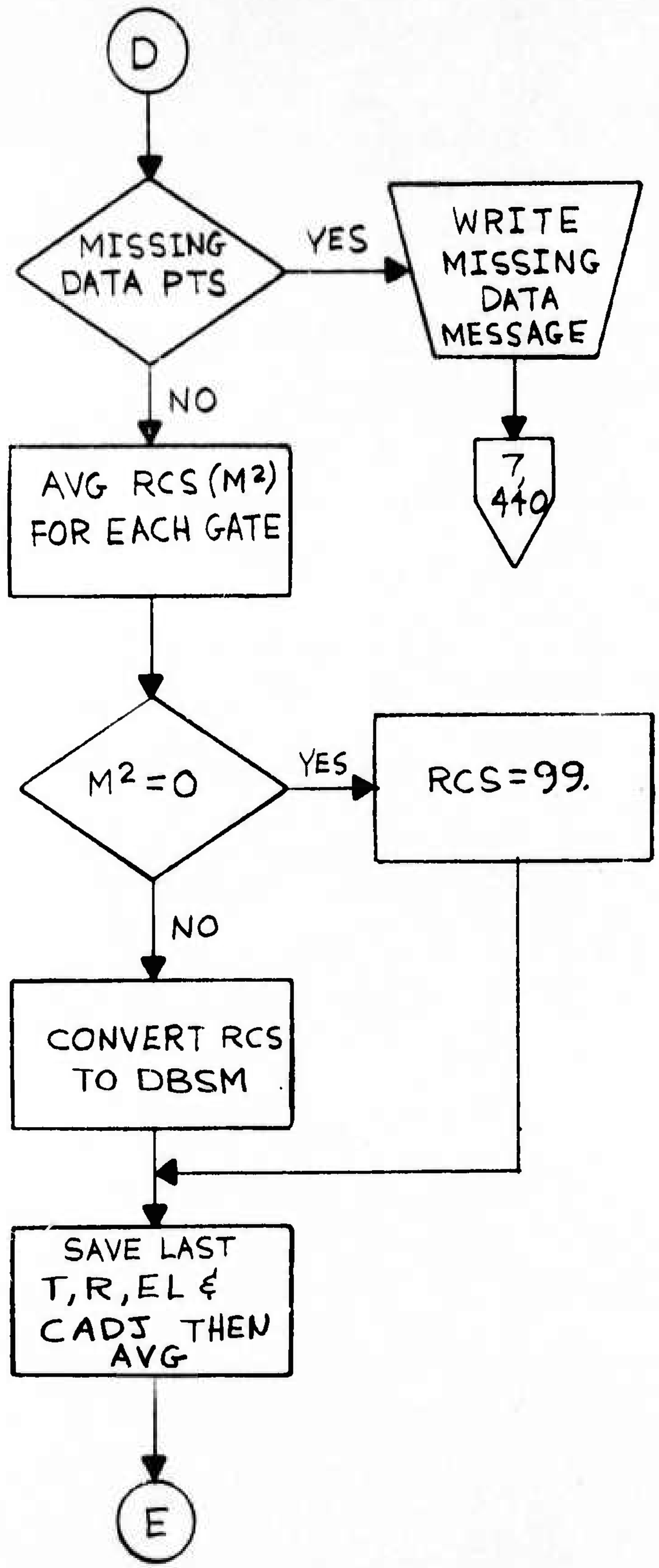


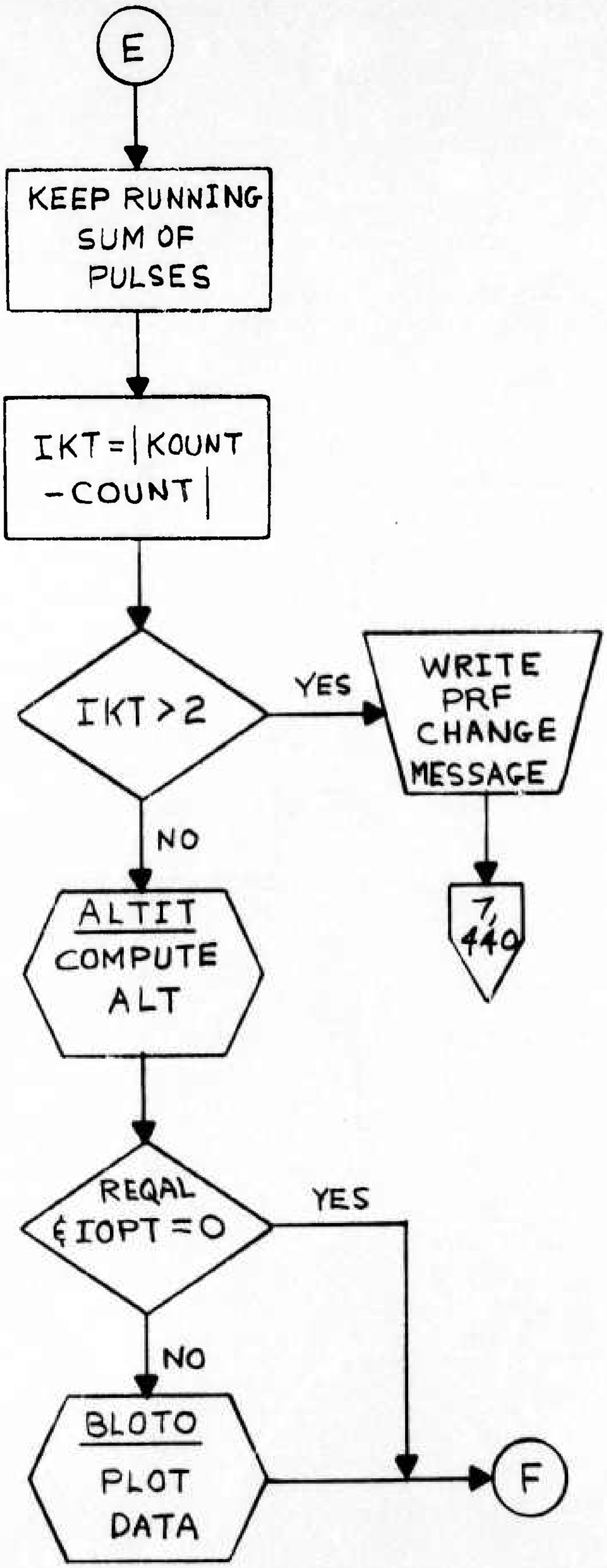


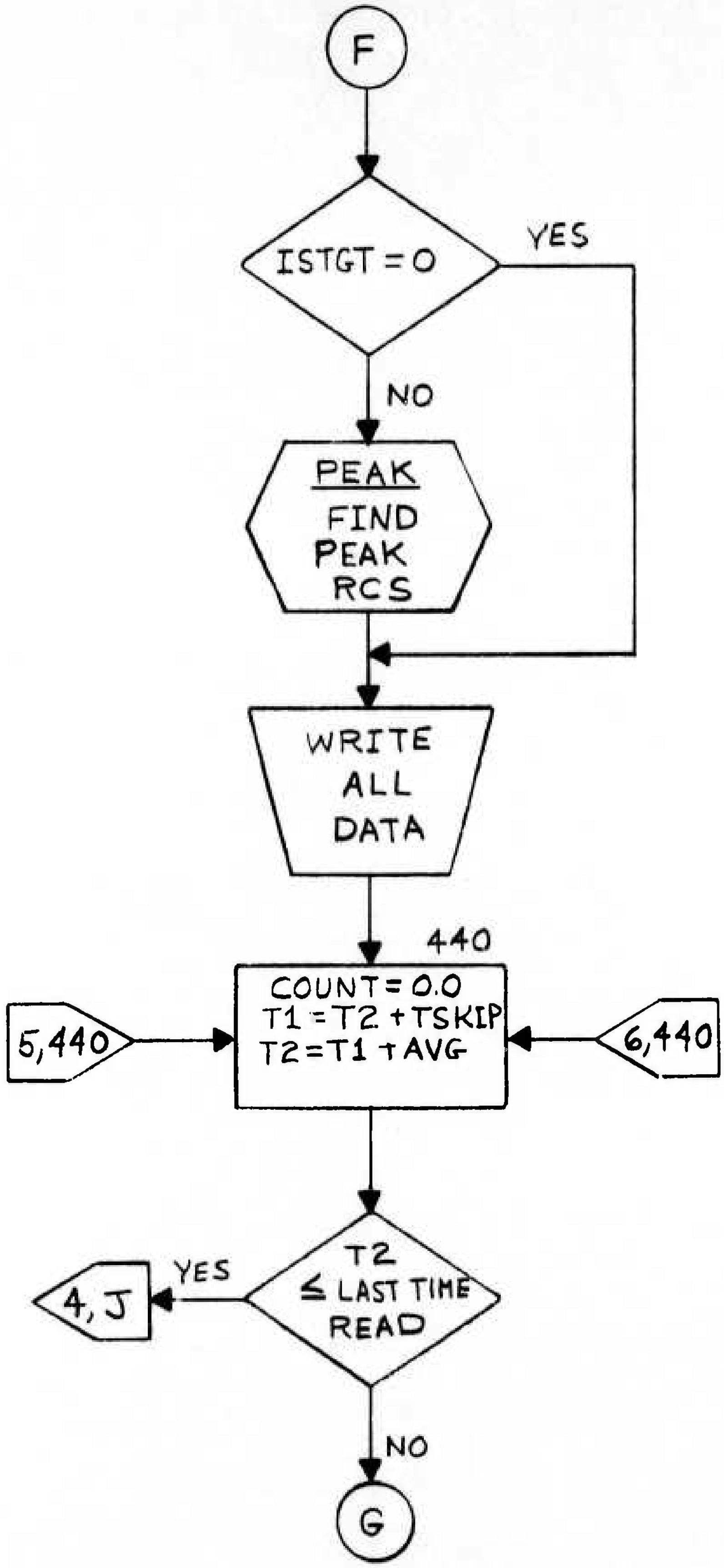
† COUNT IS PULSES IN CURRENT INTERVAL. KOUNT IS PULSES IN PREVIOUS INTERVAL.

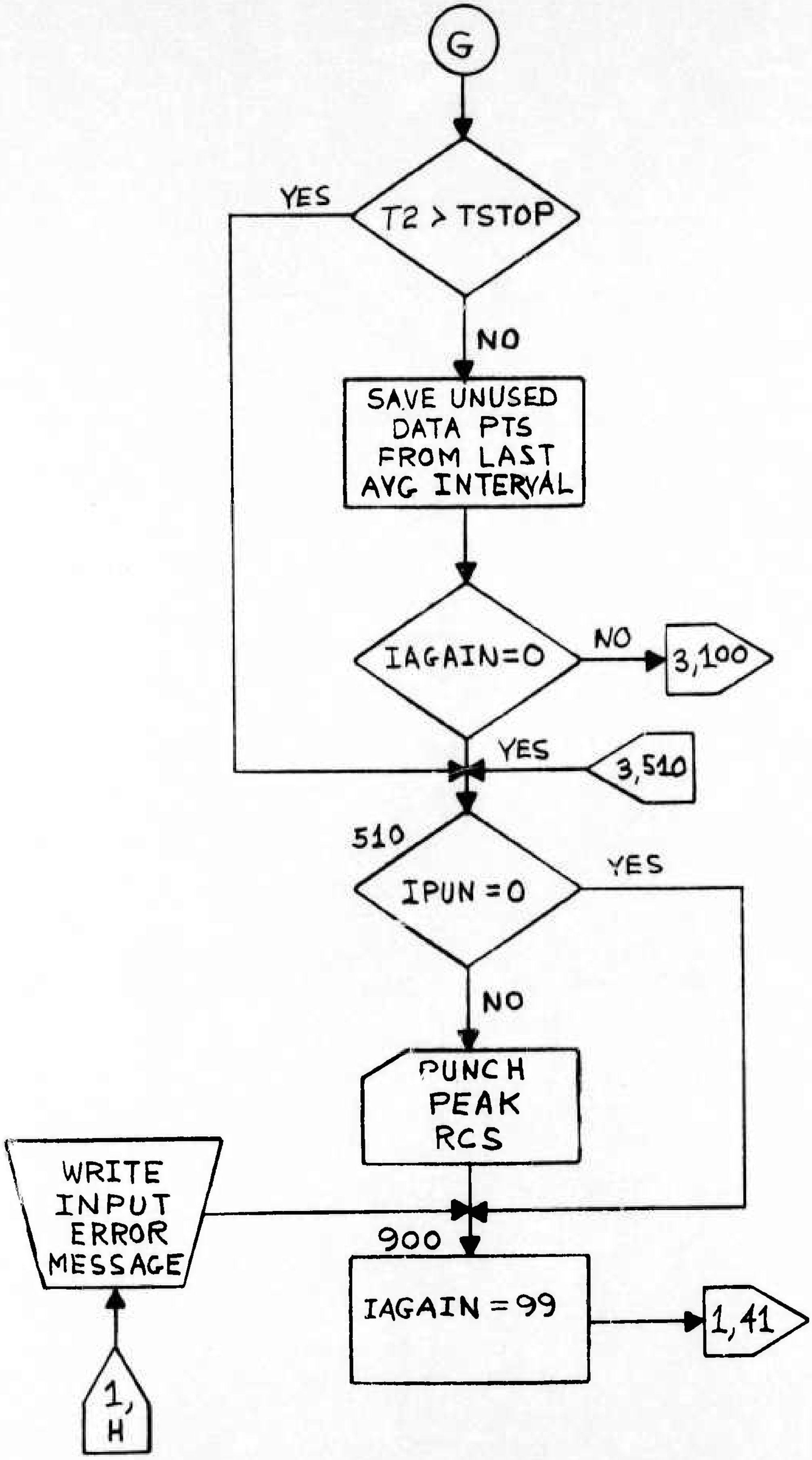

B
100
ALREAD
READ
TAPE
8,100
IAGAIN
= 55
YES
1,901
NO
NPTS=0
YES
1,41
NO
IAGAIN
= 44
YES
8,510
NO
INT=0
NO
4,I
YES
C


C
WRITE HEADING
3,I
INT=1
7,J
FIND TSTART IN DATA ARRAY
SAVE FIRST T, R, EL & CADJ OF AVG INTERVAL
CONVERT RCS TO M² TO BE AVG'D
D


D
MISSING DATA PTS
YES
WRITE MISSING DATA MESSAGE
7 440
NO
AVG RCS (M²) FOR EACH GATE
M² = 0
YES
RCS = 99.
NO
CONVERT RCS TO DBSM
SAVE LAST T, R, EL & CADJ THEN AVG
E


E
KEEP RUNNING SUM OF PULSES
IKT = |KOUNT -COUNT|
IKT > 2
YES
WRITE PRF CHANGE MESSAGE
7, 440
NO
ALTIT
COMPUTE ALT
REQAL & IOPT = 0
YES
NO
BLOTO
PLOT DATA
F


F
ISTGT = 0
YES
NO
PEAK
FIND PEAK RCS
WRITE ALL DATA
440
COUNT = 0.0
T1 = T2 + TSKIP
T2 = T1 + AVG
5,440
6,440
T2 ≤ LAST TIME READ
YES
4, J
NO
G

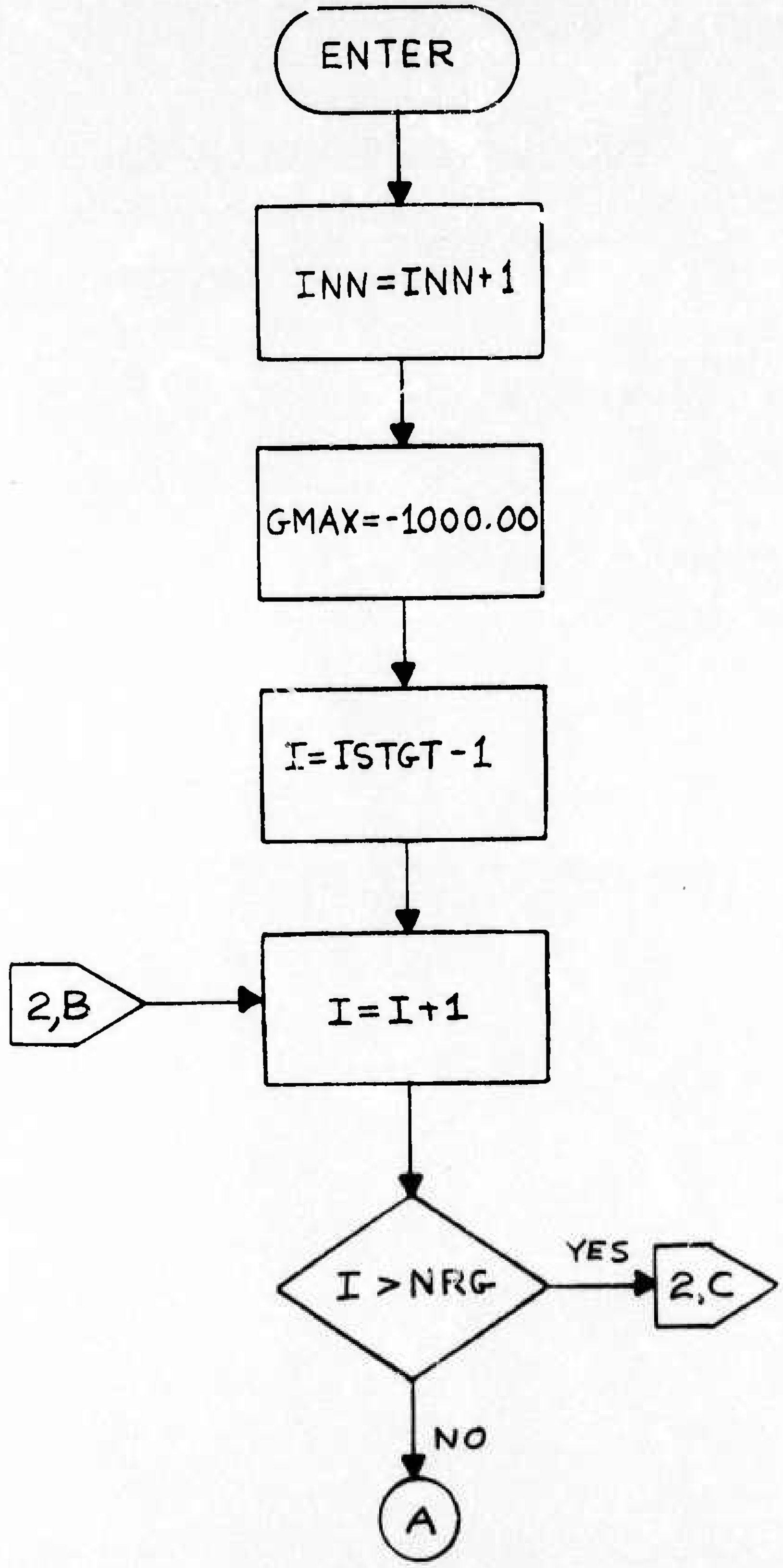

G
T2 > TSTOP
YES
NO
SAVE UNUSED DATA PTS FROM LAST AVG INTERVAL
IAGAIN=0
NO
3,100
YES
3,510
510
IPUN=0
YES
NO
PUNCH PEAK RCS
WRITE INPUT ERROR MESSAGE
900
IAGAIN = 99
1,41
1, H

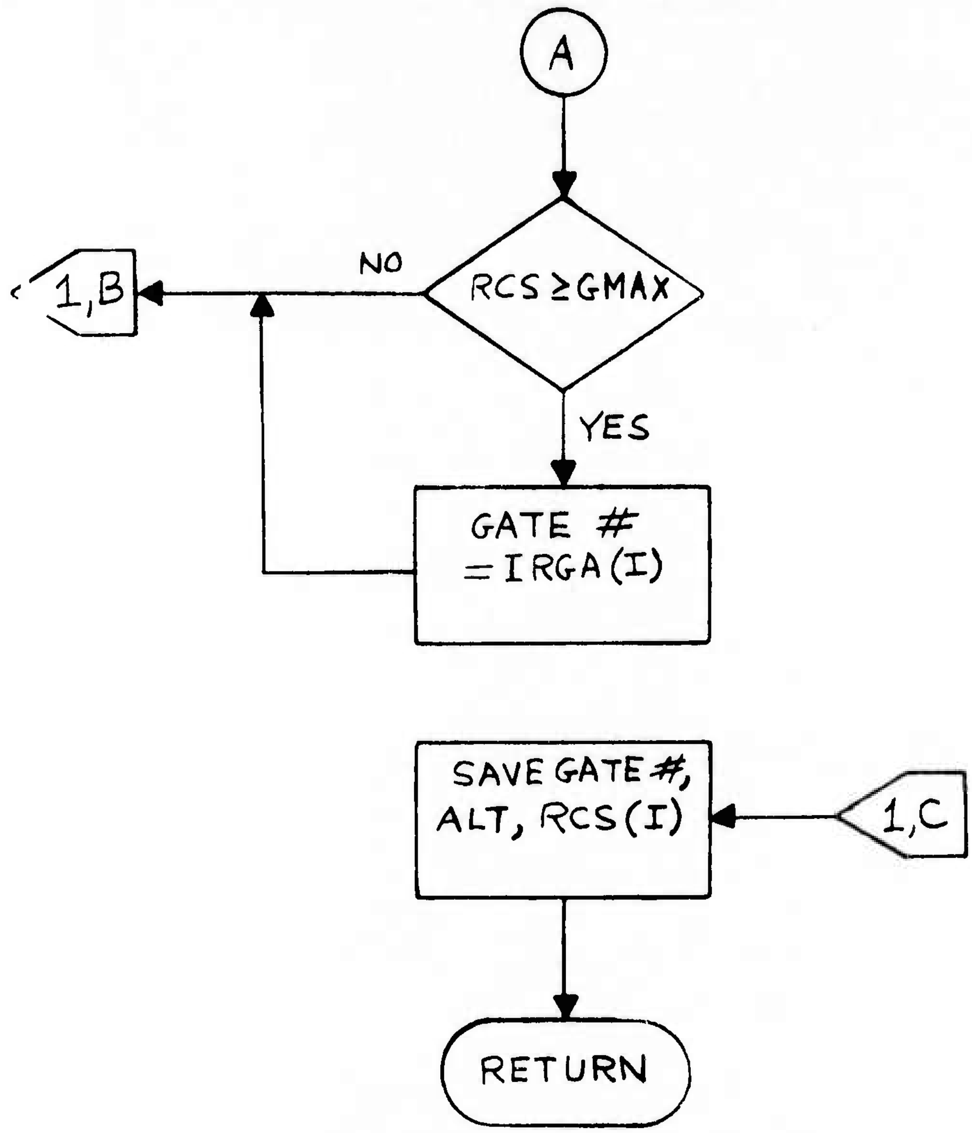
APPENDIX E
SUBROUTINE PEAK PROGRAM LISTING

```
      SUBROUTINE PEAK(AVGAL,NRG,ISTGT,IRGA,AVGSX,ISPOT)
      COMMON/PEEK/INN,GTMAX,ALT,IGAT
      DIMENSION IRGA(NRG),AVGSX(NRG),GTMAX(3000),ALT(3000),IGAT(3000)
      INN=INN+1
      GMAX=-1000.0
      DO 20 I=ISTGT,NRG
      IF(AVGSX(I).LE.GMAX)GO TO 20
      GMAX=AVGSX(I)
      IGATE=IRGA(I)
      ISPOT=I
   20 CONTINUE
      GTMAX(INN)=GMAX
      ALT(INN)=AVGAL
      IGAT(INN)=IGATE
      RETURN
      END
```

APPENDIX F

SUBROUTINE PEAK FLOW DIAGRAM

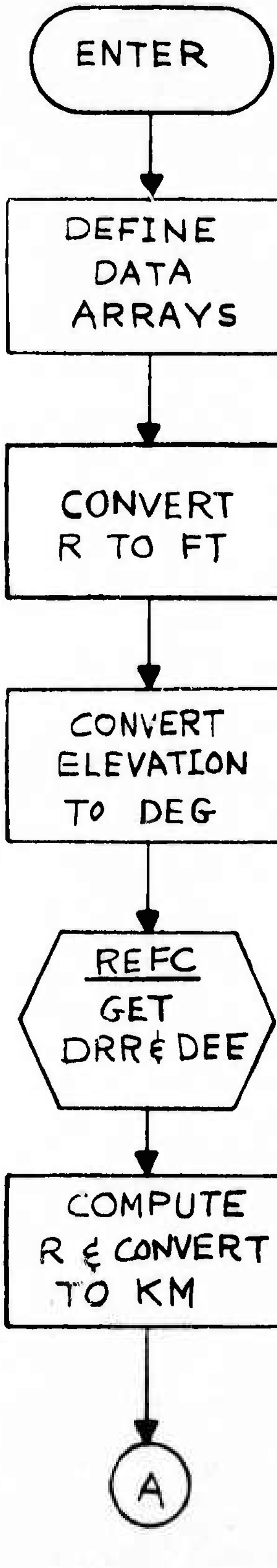


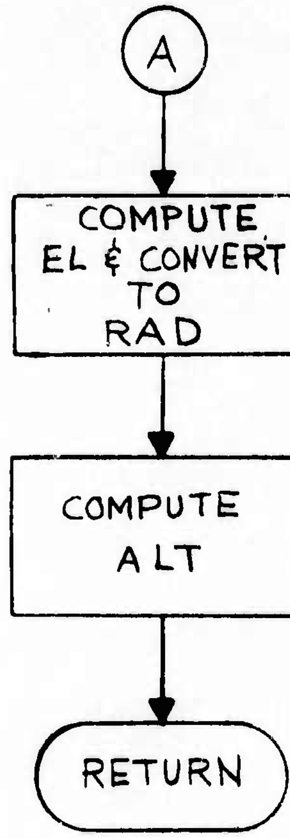

A
NO
RCS ≥ GMAX
1,B
YES
GATE #
= IRGA (I)
SAVE GATE #,
ALT, RCS (I)
1,C
RETURN

APPENDIX G
SUBROUTINE ALTIT PROGRAM LISTING

```
SUBROUTINE ALTIT(AVGAL,AVGRG,AVGEL)
DATA DR,XKMFT,RE/.0174533,.0003048,6378.145/
RR=AVGRG/XKMFT
AVGEE=AVGEL/DR
CALL REFC(AVGEE,RR,DEE,DRR)
RANGE=(RR-DRR)*XKMFT
ELEV=AVGEL-((DEE-.3)*DR)
ALT=SQRT(RANGE**2+RE**2+(2*RANGE*RE*SIN(ELEV)))
AVGAL=ALT-RE
RETURN
END
```

APPENDIX H
SUBROUTINE ALTIT FLOW DIAGRAM




A
COMPUTE
EL & CONVERT
TO
RAD
COMPUTE
ALT
RETURN

APPENDIX J

SUBROUTINE REFC PROGRAM LISTING

```
      SUBROUTINE REFC(E,R,DEE,DRR)          EFFECTIVE: 16 JUNE 1970
      DIMENSION DE(16,8),DR(16,8),ED(16),RD(8)
      DATA DE/0.0   ,0.0   ,0.0   ,0.0   ,0.0   ,0.0   ,0.0   ,0.0   ,
     10.0   ,0.0   ,0.0   ,0.0   ,0.0   ,0.0   ,0.0   ,0.0   ,0.0313,
     20.0303,0.0292,0.0287,0.0282,0.0272,0.0262,0.0253,0.0243,0.0223,
     30.0214,0.0195,0.0171,0.0135,0.0075,0.0   ,0.0937,0.0848,0.0770,
     40.0732,0.0694,0.0627,0.0571,0.0522,0.0480,0.0412,0.0385,0.0337,
     50.0278,0.0205,0.0105,0.0   ,0.1850,0.1520,0.1250,0.1140,0.1050,
     60.0904,0.0795,0.0708,0.0636,0.0523,0.0478,0.0405,0.0323,0.0229,
     70.0114,0.0   ,0.5310,0.3070,0.2120,0.1830,0.1600,0.1280,0.1060,
     80.0899,0.0780,0.0612,0.0550,0.0455,0.0354,0.0246,0.0120,0.0   ,
     90.7550,0.3120,0.2400,0.2020,0.1750,0.1370,0.1120,0.0942,0.0811,
     A0.0631,0.0566,0.0466,0.0361,0.0250,0.0122,0.0   ,0.9120,0.4110,
     B0.2560,0.2140,0.1840,0.1420,0.1150,0.0967,0.0830,0.0643,0.0575,
     C0.0472,0.0365,0.0252,0.0122,D.0   ,0.9700,0.4200,0.2600,0.2200,
     D0.1900,0.1460,0.1170,0.0980,0.0840,0.0653,0.0584,0.0478,0.0369,
     E0.0254,0.0123,0.0 /
      DATA DR/  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
     1  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0, 22.6, 21.5, 20.4, 19.9,
     2 19.4, 18.5, 17.6, 16.8, 16.1, 14.8, 14.2, 13.2, 12.0, 10.4,  8.6,
     3  7.7, 67.3, 57.9, 50.2, 47.0, 44.1, 39.3, 35.4, 32.1, 29.3, 24.8,
     4 22.9, 19.7, 16.3, 12.7,  9.4,  8.1,132.0, 98.5, 77.4, 69.7, 63.2,
     5 52.9, 44.7, 38.4, 33.4, 26.4, 23.9, 20.1, 16.4, 12.7,  9.4,  8.1,
     6340.0,167.0,103.0, 86.1, 73.4, 56.7, 46.2, 38.9, 33.6, 26.4, 24.0,
     7 20.2, 16.4, 12.8,  9.5,  8.2,405.0,170.0,104.0, 86.3, 73.6, 56.8,
     8 46.3, 38.9, 33.7, 26.5, 24.1, 20.3, 16.5, 12.8,  9.5,  8.2,421.0,
     9171.0,104.0, 86.6, 73.9, 57.1, 46.4, 39.0, 33.8, 26.8, 24.3, 20.5,
     A 16.6, 13.0,  9.8,  8.4,446.0,172.0,105.0, 87.4, 74.0, 58.0, 46.6,
     8 39.2, 34.0, 27.0, 24.6, 20.7, 16.7, 13.0, 10.0,  8.4/
      DATA ED,RTDEG/0.01,2.0,4.0,5.0,6.0,8.0,10.0,12.0,14.0,18.,20.,
     124.,30.,40.,60.,90.,57.29578/
      DATA RD/0.01,10.,30.,60.,200.,400.,1000.,2000./
      IF(R.LE.0.0)GO TO 300
      RG=R/6080.27
      DO 100 IED=2,15
      I=17-IED
      IF(E.GE.ED(I))GO TO 120
100   CONTINUE
      I=1
120   DO 200 JRD=2,8
      J=10-JRD
      IF(RG.GE.RD(J))GO TO 220
200   CONTINUE
      J=1
220   IF(J.EQ.8)GO TO 340
      ZR=ALOG(RG/RD(J))/ALOG(RD(J+1)/RD(J))
      IF(E.LE.0.0)GO TO 320
      ZE=ALOG(E/ED(I))/ALOG(ED(I+1)/ED(I))
      DE1=((DE(I+1,J)-DE(I,J))*(1.-ZR)+(DE(I,J+1)-DE(I,J))*ZR)*ZE
      DE2=((DE(I,J+1)-DE(I,J))*(1.-ZE)+(DE(I+1,J+1)-DE(I,J+1))*ZE)*ZR
      DEE=DE1+DE2+DE(I,J)
      DR1=((DR(I+1,J)-DR(I,J))*(1.-ZR)+(DR(I,J+1)-DR(I,J))*ZR)*ZE
      DR2=((DR(I,J+1)-DR(I,J))*(1.-ZE)+(DR(I+1,J+1)-DR(I,J+1))*ZE)*ZR
      DRR=(DR1+DR2+DR(I,J))
      GO TO 400

300   DEE=0.0
      DRR=0.0
      GO TO 400
320   DEE=DE(I,J)+(DE(I,J+1)-DE(I,J))*ZR
      DRR=DR(I,J)+(DR(I,J+1)-DR(I,J))*ZR
      GO TO 400
340   DELT=(E-ED(I))/(ED(I+1)-ED(I))
      DEE=DELT*(DE(I+1,J)-DE(I,J))+DE(I,J)
      DRR=DELT*(DR(I+1,J)-DR(I,J))+DR(I,J)
400   RETURN
      END
```

APPENDIX K

SUBROUTINE TSPLIT PROGRAM LISTING

```
      SUBROUTINE TSPLIT(AVGTM,IHM,TRUN)
      DIMENSION IHM(2),DIVIDE(2)
      DOUBLE PRECISION AVGTM,TRUN
      DATA DIVIDE/3600.,60./
      TRUN=AVGTM
      DO 20 I=1,2
      IHM(I)=TRUN/DIVIDE(I)
      TRUN=TRUN-FLOAT(IHM(I))*DIVIDE(I)
20    CONTINUE
      RETURN
      END
```